IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, *et al.*,	)	
	)	
Plaintiffs,	)	
	)	
v.	)	**Case No. 4:05-cv-00329-GKF-PJC**
	)	
TYSON FOODS, INC., *et al.*,	)	
	)	
Defendants.	)	
	)	

DEFENDANTS' MOTION TO EXCLUDE TESTIMONY OF DR. BERNARD ENGEL PURSUANT TO *DAUBERT v. MERRELL PHARMACEUTICALS, INC.*

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INTRODUCTION

Defendants respectfully move the Court for an order excluding certain opinions and testimony of Dr. Bernard Engel as unreliable under Federal Rule of Evidence 702. *Daubert v. Merrell Pharms, Inc.*, 509 U.S. 579 (1993). Dr. Engel claims to be able to predict the phosphorus loads to Lake Tenkiller 50 and even 100 years from now based on various hypothesized changes to the size of the poultry industry and the extent of poultry litter applications in the Illinois River Watershed ("IRW"). Dr. Engel further claims to have quantified the percentage of the total estimated phosphorus load that reaches Lake Tenkiller that is attributable to run off from pastures receiving poultry litter each year from 1998 to 2006.[1] These claims and opinions are based upon poorly constructed and unrealistic computer models and a series of untested and novel computational methods.

The modeling and load allocation work by Dr. Engel is riddled with errors and based upon flawed assumptions that bear no resemblance to the real-world conditions or activities in the IRW. Dr. Engel also failed to properly calibrate, validate or test his model in accordance with generally accepted practices and directly applicable EPA guidance. The alternative universe created by Dr. Engel with his computer models bears no resemblance to the real IRW. His predictions based upon the results of these models will not assist the trier of the fact in this case because those predictions are the product of unfounded assumptions or deliberate manipulations. Simply put, the opinions offered by Dr. Engel based upon the modeling and

[1] Dr. Engel has issued a lengthy report in this matter consisting of 100 pages of text and figures in the main body of the report and seven separate appendices containing a combined 140 additional pages. *See* Ex. 1, Engel Rpt. Excerpt (5/22/08), p. i (table of contents). The opinions and claims challenged in this motion relate only to the hydrologic modeling and phosphorus source allocation work completed by Dr. Engel and Dr. Ji-Hong and described in Section 10 (pp. 47-94) and Appendix F (Contribution of Cattle in Streams to P Loads in the IRW) and summarized on pages 2-3 of the main body of the report.

source allocation work do not meet the reliability standards of *Daubert* and Rule 702 of the Federal Rules of Evidence. For these reasons, Dr. Engel's testimony related to these matters should be excluded.

BACKGROUND

Dr. Bernard Engel is an agricultural and biological engineer. He was retained by the Plaintiffs in this case to offer opinions on various topics including the potential transport of phosphorus from different potential sources throughout the one million acre watershed to streams and rivers in the IRW and ultimately downstream to Lake Tenkiller. These opinions rest largely upon the results of a hydrologic computer model known as GLEAMS[2] and a phosphorus routing model that he developed and used for the first time in connection with this case.[3] Dr. Engel used the results or output from these computer simulations in a series of novel and fundamentally flawed calculations to arrive at an "allocation" of the total phosphorus load reaching Lake Tenkiller to assumed but unidentified poultry litter applications in the IRW. Ex. 1, Engel Rpt. (5/22/08), pp. 93-94.

According to Dr. Engel, "poultry waste application within the IRW represents 45% of the P loads to Lake Tenkiller between 1998 and 2006 and 59% of the P loads to Lake Tenkiller for

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[2] GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) is a field-scale hydrologic model originally developed by the University of Georgia to model transport of substances from agricultural fields to groundwater. Ex. 5, Bierman Rpt., p. 4.

[3] What Dr. Engel calls his "routing model" is an equation that he and Dr. Ji-Hong developed for this case to force the combined known point source loads in the IRW and the predicted nonpoint source loads simulated by GLEAMS to match the estimated total phosphorus loads that reach the three USGS gauging stations in the IRW that are closest to Lake Tenkiller. The "routing model" equation used by Dr. Engel and Dr. Ji-Hong is: P Load to Lake = a + b * Q * P Accumulation + c * Q^2 * P Accumulation. Ex. 1, Engel Rpt. (5/22/08), p. D-21. Dr. Engel admitted in his deposition that his routing model has no physical meaning and does not represent or simulate the actual physical processes in the IRW that determine in the real world whether a molecule of phosphorus entering a stream at a particular location will be transported downstream to Lake Tenkiller. Ex. 2, Engel Dep., p. 191 ("It's not modeling those physical processes.") and p. 187 ("Q. Does your phosphorus routing model include any physically based parameters that would assist you in allocating phosphorus back to sources in the watershed? A. No . . .").

the years 2003-2006." Ex. 1, Engel Rpt. (5/22/08), p. 93. Nowhere in his report does Dr. Engel explain the methodology that he used to convert the results of his computer models into the quantitative opinions concerning the relative contribution poultry litter applications. When questioned about the lack of explanation of this important opinion in his deposition, Dr. Engel's only response was "looks like that may have been something that was not fully addressed in the rush to meet the deadline." Ex. 2, Engel Dep., p. 337.[4] In addition to simulating the historical loading of phosphorus to Lake Tenkiller, Dr. Engel claims that his computer modeling allows him to predict what the total phosphorus loads to this system will be 10, 20, 50 and even 100 years into the future if certain events transpire (i.e., poultry litter application rates remain constant, poultry litter application rates increase, poultry litter application is banned). Ex. 1, Engel Rpt. (5/22/08), pp. 48-92.

Dr. Engel admittedly has some professional and academic experience in using hydrologic computer models to evaluate fate and transport issues in an environmental setting.[5] However,

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[4] The deadline referenced is the expert report deadline that had been known to Plaintiffs for years and moved back several times at their request. In his "rush" to meet the deadline, Dr. Engel also failed to include basic information necessary to interpret the numerous figures and charts contained with his original report. *See* Ex. 1, Engel Rpt (5/22/08), p. D-32, Figure 15 (x and y axis of charts labeled generically series one and linear series one). This practice was continued in his first errata report issued four months later. *See* Ex. 3, Engel First Errata Rpt., App. D. When asked at his deposition to explain these omissions, Dr. Engel's only response was "I was lazy." Ex. 2, Engel Dep., p. 223. Dr. Engel's laziness, or perhaps more accurately his lack of carefulness and attentiveness, precludes defendants and the Court from fully understanding the results of his work or placing any confidence in those results. For example, due to Dr. Engel's "oversight" in properly labeling the charts and figures in his report, we do not even know whether his predicted phosphorus loads to Lake Tenkiller shown in those charts are in pounds or kilograms. Ex. 2, Engel Dep., pp. 224-25.

[5] Plaintiffs will undoubtedly tout Dr. Engel's selection as an expert for the court in 2003 in the Northern District case of *City of Tulsa v. Tyson Foods, Inc.*, N.D. Okla. Case No. 01-CV-900-EA. A copy of Dr. Engel's testimony at the March 4, 2003, *Daubert* hearing in that case is attached as Exhibit 3. Dr. Engel's selection as a court expert in that case is immaterial to the reliability of his work in this case. Dr. Engel performed no hydrologic modeling in that case nor did he offer an opinion as to the relative contribution of poultry litter or any other source of nutrients to the overall phosphorus load to the reservoirs involved in that case. Instead, Dr.

Defendants are unaware of any instance in which Dr. Engel has been allowed to offer the type of predictive modeling and quantitative load allocation opinions contained in his report for the purpose of assigning liability to parties in litigation. Furthermore, much of the hydrologic modeling and load allocation work at issue in this motion was actually performed by a twenty-five year old Purdue University post-doctoral associate named Dr. Ji-Hong who completed much of the work after he returned home to South Korea in January of 2008. Ex. 2, Engel Dep., pp. 6-9, 50, 464-75. Dr. Ji-Hong was the person responsible for actually setting up and running the GLEAMS computer model. *Id.*, pp. 38-40, 46-47. Dr. Ji-Hong also created a new computer program to develop the coefficients Dr. Engel used to drive his phosphorus routing model. Dr. Ji-Hong set up the input data files and selected the default values used in various computer simulations upon which Dr. Engel's opinions are based. *Id.*, pp. 38-40. The computer code used in the purported "calibration" of the model was also written and developed by Dr. Ji-Hong specifically for this project. *Id.*, pp. 34-38.

While Plaintiffs will undoubtedly claim that Dr. Engel was intimately involved in every aspect of the modeling and load allocation work by Dr. Ji-Hong, the truth is that Dr. Engel is incapable of explaining what Dr. Ji-Hong did to generate the modeling results and load allocations that appear in his report.[6] For example, Dr. Engel was unable for over a month to

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Engel simply reviewed the modeling work of an expert for the plaintiffs in that case and assisted the court in evaluating the opinions offered based upon the results of a different hydrologic model than the one involved here. As is discussed below, Dr. Engel surprisingly committed many of the same mistakes in his modeling work in this case that he criticized the expert in the *City of Tulsa* case for committing.

[6] As it turns out, much of Dr. Engel's report is simply a borrowing by him of the work and opinions of other consultants hired by Plaintiffs. In addition to the modeling and load allocation work of Dr. Ji-Hong, Dr. Engel apparently intends to testify about: (a) the Mass Balance report authored by Megan Smith (Alexander Consulting) which appears as Appendix B to his report, and (b) the report on the alleged correlation of river P concentrations with poultry house density authored by Tim Cox (Camp, Dresser & McKee) which appears as Appendix C to this report. *See* Ex. 1, Engel Rpt., App. B and C.

answer basic questions posed by Defendants about the "calibration" of the GLEAMS model because Dr. Ji-Hong was on vacation and unable to explain the steps to Dr. Engel. Ex. 2, Engel Dep., pp. 52-54. Dr. Engel cannot explain the basis for the manual modifications made by Dr. Ji-Hong to input parameters used in the GLEAMS model. *Id.*, pp. 55-56. Dr. Engel did not know that Dr. Ji-Hong had configured the GLEAMS model to treat urban land use areas as alfalfa hay pastures. *Id.*, pp. 155-56. Dr. Engel did not know whether Dr. Ji-Hong set up the GLEAMS model to apply poultry litter or commercial fertilizer to cropland in the IRW. *Id.*, pp. 314-15.

Most importantly, Dr. Engel is unable to explain the source allocation calculations performed in part by Dr. Ji-Hong or to identify the source of the figures used in arriving at his ultimate opinion that 45% or 59%, depending upon the time frame, of the P load to Lake Tenkiller was the result of poultry litter applications.[7] In fact, after being presented with and questioned about the spreadsheets showing the figures used by Dr. Ji-Hong to arrive at the load allocations, Dr. Engel indicated that he "would probably want to recheck this [i.e., the 45% and 59% allocations in his report] at this stage given some of the questions you've raised. . . ." Despite repeated requests by Defendants, Plaintiffs and Dr. Engel have refused to provide contact information for Dr. Ji-Hong or to take a position on whether Defendants are free to contact Dr. Ji-Hong to obtain explanations of the aspects of the modeling and load allocation work that Dr. Engel was incapable of explaining. *Id.*, p. 413.

The modeling and source allocation work put forward by Dr. Engel has been riddled with

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[7] Ex. 2, Engel Dep., p. 341 ("there were portions of that performed by Dr. Ji-Hong and portions of that performed by myself."); pp. 383-84 (Dr. Engel could not confirm whether the results of his phosphorus routing model were used in the "allocation spreadsheet" used by Dr. Ji-Hong to quantify contributions); pp. 385-86 (Dr. Engel does not know what GLEAMS scenarios or model runs were used by Dr. Ji-Hong to generate the results used to allocate P loads to poultry litter); and pp. 389 (Dr. Engel could not identify the source of the 260,983 pounds of phosphorus from pasture land use that was integral to Dr. Ji-Hong's allocation of P loads to P litter.)

errors which cast serious doubt on the accuracy and reliability of the opinions he intends to offer at trial based upon this work. Since issuing his expert report on May 22, 2008, Dr. Engel has had to correct or entirely replace the portions of his report relating to the modeling and source allocation opinions on two different occasions due to substantial mistakes in his work. *See* Ex. 4, Engel Errata Rpt. (9/4/08) (making 44 pages of substantive changes to the modeling and load allocation portions of the original report); Ex. 5, Engel Second Errata Rpt. (10/17/08) (consisting of a letter from Plaintiffs' counsel purporting to correct mistakes made by Dr. Engel in his first errata report). These errors had a significant impact on the results of the modeling work and the opinions expressed by Dr. Engel based upon that work.[8] Even more troubling than the fact that so many substantial mistakes were made by Dr. Engel and Dr. Ji-Hong is that these mistakes were identified *by Defendants' expert* and not by Dr. Engel. Ex. 2, Engel Dep., pp. 39, 66-67. The inability of Dr. Engel to identify mistakes in his own work or in the work of his assistant Dr. Ji-Hong precludes the parties and the Court from placing any confidence on the hydrologic modeling and source allocation opinions that Plaintiffs seek to have Dr. Engel offer at the trial of this matter.[9]

Defendants had the modeling and source allocation work of Dr. Engel and Dr. Ji-Hong reviewed by Dr. Victor Bierman. Dr. Bierman is a senior scientist with the firm of LimnoTech. LimnoTech regularly works with industry and organizations such as the EPA and U.S.

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[8] Ex. 2, Engel Dep., pp. 71-74 (prediction in original report that P loads to Lake Tenkiller decline after 30 years of additional litter applications "corrected" in first errata report to predict that P loads would increase for a period of 30 years and then stabilize); p. 78 (prediction in original report that P load to Tenkiller would be reduced by 16% in the next 10 years if no litter is applied "corrected" to 18% in first errata report); and pp. 80-82 (70% allocation of P load to poultry litter 50 years into the future in original report "corrected" to 92% in first errata report).

[9] Dr. Engel's explanation that one of the mistakes was a product of erroneous computer code written by Dr. Ji-Hong to help "calibrate" the GLEAMS model and that Dr. Engel was unaware of this error because of Dr. Ji-Hong's lack of proficiency in the English language made communications between the two difficult hardly instills confidence in the results of their joint work on this project. Ex. 2, Engel Dep., pp. 34-35, 51-52.

Department of Justice on environmental matters. Dr. Bierman is an environmental engineer with 35 years experience in the development and application of water quality models. He has worked on environmental projects involving water bodies such as the Great Lakes, the Florida Everglades and the Gulf of Mexico. *See* Ex. 6, Bierman Rpt., A1-A29 (Curriculum Vitae). Dr. Bierman's report summarizes the more significant errors, flaws and inconsistencies noted in his review of the modeling and source allocation work of Dr. Engel. *See* Ex. 6, Bierman Rept., pp. 1-38. The problems identified by Dr. Bierman include, among other things, the use of an inappropriate model, unfounded assumptions about conditions in the IRW, breaches of generally accepted practices in the scientific community, failures to adhere to EPA guidance and the failure to properly calibrate, validate and test the models.[10]

DISCUSSION

Federal Rule of Evidence 702 charges a district court to ensure that "all scientific testimony ... is not only relevant, but reliable." *Daubert*, 509 U.S. at 589. In applying *Daubert*, the Court should examine a number of factors including:

> (1) whether the opinion has been subjected to testing or is susceptible of such testing; (2) whether the opinion has been subjected to publication and peer review; (3) whether the methodology used has standards controlling its use and known rate of error; (4) whether the theory has been accepted in the scientific community.

Truck Ins. Exch. v. MagneTek, Inc., 360 F.3d 1206, 1210 (2004). These factors assist the Court in assessing the degree to which an experts' opinion is founded on proper scientific

[10] In addition to problems with the methodologies employed by Dr. Engel and Dr. Ji-Hong, Dr. Bierman also noted a large number of operational "errors, internal inconsistencies, incorrect unit conversions, incorrect labeling, missing files and missing or incomplete documentation" with respect to the expert report of Dr. Engel. Ex. 6, Bierman Rpt., p. 28. A partial listing of these mistakes appears in Appendix E to Dr. Bierman's report. The number and nature of these mistakes is so substantial that Dr. Bierman stated that Dr. Engel's "work does not meet the normal standards for scientific credibility or utility for the support of environmental decisions. . . ." *Id.*

methods. "The adjective 'scientific' implies a grounding in the methods and procedures of science." *Daubert*, 509 U.S. at 590.

The *Daubert* analysis explores both an expert's general methodology, as well as its specific application in the case at bar. As the Tenth Circuit has explained, "any step that renders the analysis unreliable renders the expert's testimony inadmissible[,] whether the step completely changes a reliable methodology or merely misapplies that methodology." *Mitchell*, 165 F.3d at 782 (quotations omitted; italics added). An "expert['s] conclusions are not immune from scrutiny: 'A court may conclude that there is simply too great an analytical gap between the data and the opinion proffered.'" *Hollander v. Sandoz Pharms. Corp.*, 289 F.3d 1193, 1205-06 (10th Cir. 2002) (quoting *Joiner v. General Elec.*, 522 U.S. 136, 147 (1997)). When considered in light of these requirements, the methodologies employed by Dr. Engel in his modeling and source allocation work and the conclusions he reaches based upon that work fall well short of the standard for reliable scientific evidence under *Daubert*.

A. Dr. Engel's Methodology is Novel and Has Not Been Subjected to Peer-Review within the Scientific Community

As the Tenth Circuit has observed, whether a methodology was developed independent of litigation and has been subjected to peer review are "important *Daubert* considerations". *Norris v. Baxter Healthcare Corp.*, 397 F.3d 878, 886 (10th Cir. 2005). Conversely, scientific theories generated solely for the purpose of litigation are suspect: "[A] scientist's normal workplace is the lab or the field, not the courtroom or the lawyer's office." *Daubert II*, 43 F.3d at 1317-18. Indeed, hired expert testimony can "turn[] scientific analysis on its head, ... reason[ing] from an end result in order to hypothesize what needed to be known but what was not." *Mitchell v. Gencorp, Inc.*, 165 F.3d 778, 782 (10th Cir. 1999); *see also Cabrera v. Cordis Corp.*, 134 F.3d 1418, 1420-21 (9th Cir. 1998); *Sorenson v. Shaklee Corp.*, 31 F.3d 638, 649 (8th Cir. 1994).

Peer review and publication in particular provide "a significant indication that [an expert's work] is taken seriously by other scientists." *Daubert v. Merrell Dow Pharms., Inc.* (*Daubert II*), 43 F.3d 1311, 1318 (9th Cir. 1995); *accord Truck Ins.*, 360 F.3d at 1210; *Bitler v. A.B. Smith Corp.*, 400 F.3d 1227, 1233. Ultimately, "the examination of a scientific study by a cadre of lawyers is not the same as its examination by others trained in the field of science or medicine." *Perry v. United States*, 755 F.2d 888, 892 (11th Cir. 1985); *see Allgood v. GM Corp., 2006 WL 2669337*, at **17-18 (S.D. Ind. Sept. 18, 2006) (rejecting as novel a source tracking methodology that employed a "ratio analysis" to establish a causal pathway). While peer review does not guarantee validity, it will "increase the likelihood that substantive flaws in methodology will be detected." *Daubert*, 509 U.S. at 593.

The work and methods of Dr. Engel have not been subjected to peer review. To the contrary, many important aspects of the modeling and source allocation methodology he used in this case were developed for the first time within the context of this litigation. These methods have not been subjected to peer-review much less attained general acceptance within the scientific community. For example, the phosphorus routing model used by Dr. Engel was created specifically for this project and includes equations and coefficients that have never been used before by any other scientist to simulate the phosphorus transport and in-stream processes that occur in tributary system such as the IRW. Ex. 2, Engel Dep., pp. 190-92.[11]

Similarly, and perhaps more importantly, the method used by Dr. Engel and Dr. Ji-Hong outside of the computer models to allocate the total predicted phosphorus load back to sources such as poultry litter applications is a novel method developed and used for the very first time in

[11] When asked whether he had independently tested his phosphorus model to determine if it is a valid and realistic simulation of what actually happens in the stream systems in the Illinois River Watershed, Dr. Engel simply declared "there is no reason to perform that test. It's not – it's not necessary for the project." Ex. 2, Engel Dep., p. 192.

this litigation.[12] These computational methods are the source of the ultimate opinion by Dr. Engel that "poultry waste application within the IRW represents 45% of the P loads to Lake Tenkiller between 1998 and 2006 and 59% of the P loads to Lake Tenkiller for the years 2003-2006." Ex. 1, Engel Rpt. (5/22/08), p. 93. These methods have never before been described in any piece of peer-reviewed scientific literature. Ex. 2, Engel Dep., pp. 345-48.

B. Dr. Engel Misapplied the GLEAMS Model and Configured that Model in an Unrealistic and Unreliable Manner

Plaintiffs may argue that the conclusions reached by Dr. Engel are inherently reliable because he used a model that has been used by others in the scientific community and is the subject of various peer-reviewed, published papers. Of course, whether the GLEAMS model has ever been used in some other setting by someone other than Dr. Engel to produce reliable and realistic results is not the test for admissibility of Dr. Engel's opinions in this case. The issue presently before the Court is whether Dr. Engel's work and opinions in this case are reliable. The mere fact that Dr. Engel's work involved an application of the GLEAMS model does not insulate Dr. Engel's work and opinions from review under *Daubert*.

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[12] Dr. Engel had to develop a source allocation method outside of the computer models because neither the GLEAMS model nor his phosphorus routing model were capable of tracking sources or allocating phosphorus loads at Lake Tenkiller back to sources. Ex. 2, Engel Dep., p. 344 ("Q. So is it true, Dr. Engel, that GLEAMS does not have the ability in and of itself to predict the amount of phosphorus that is originating from poultry litter as opposed to forest, crop, urban and pasture [land uses]? A. Well, the model, without interpreting the results, you know, is not identifying poultry litter as the phosphorus source. So, you know, it's going to require one's interpretation of those results in order to, you know, to arrive at a poultry contribution.") and p. 202 ("Q. So your phosphorus routing equation really tells you nothing about the source of phosphorus that reaches Lake Tenkiller, is that fair? A. Correct. This equation is not identifying the sources.") Given the limitations of these computer models, Dr. Engel and Dr. Ji-Hong derived a new methodology for use in this case to take the total phosphorus load predicted by GLEAMS for the pasture land use category and "break it down" or allocate it back to sources of phosphorus that Dr. Engel and Dr. Ji-Hong believed might have contributed to these total predicted loads. *Id.*, p. 345.

In considering a *Daubert* challenge, a district court should both examine the general methodology used by the expert theory and also assess the reliability of the expert's application of a particular methodology to the data and facts of the particular case at hand. Specifically, the district court "'must assess the reasoning and methodology underlying the expert's opinion, then determine whether it is scientifically valid and applicable to a particular set of facts." *United States v. Benally*, 541 F.3d 990, 994 (10th Cir. 2008) (quoting *Burlington N.*, 505 F.3d at 1030) (emphasis added); *see also Norris*, 397 F.3d at 885-86 (same); *Dodge v. Cotter*, 328 F.3d 1212, 1221 (10th Cir 2003) (same). The way in which Dr. Engel applied the GLEAMS model to the set of facts involved in this case is far from a scientifically valid methodology.

First, the GLEAMS model is not an appropriate model for evaluating contribution of various sources and transport across the large and diverse landscape of the IRW. As part of its TMDL program, EPA has published a report entitled *TMDL Model Evaluation and Research Needs* in which it has evaluated commonly used hydrologic models. *See* Ex. 7, *TMDL Model Evaluation and Research Needs* (2005) (the "EPA Report on Models"). According to EPA, GLEAMS is a "field-scale model that assumes that a field has homogenous land use, soils and precipitation." *Id.*, p. 210. It is "not suited for bigger watersheds" and provides "no support for receiving waters" (i.e., it is not a watershed model and it cannot simulate transport of constituents from the edge of field to a stream or lake). *Id.*, pp. 210-11. The EPA Report on Models specifically states the GLEAMS model should be "limited to an agricultural field of a very small size" and that it is "not suited for urban land uses." *Id.*, p. 211. Dr. Engel violated EPA's recommendations when he applied what is essentially a field-scale model to a watershed modeling exercise. The IRW is a large watershed, consisting of over 1.1 million acres of land. A substantial portion of the watershed is comprised of the very urban land uses that EPA has said GLEAMS is not suited to model. The GLEAMS model should not have been applied to this

project.[13] In fact, the GLEAMS model has never been accepted by any court as a proper basis for assigning liability to alleged pollution sources within a watershed such as the IRW. Ex. 2, Engel Dep., p. 460.

Even if the GLEAMS model could have been used properly to model the 1.1 million acre IRW, the skewed and unrealistic set up of the model by Dr. Engel prevent this Court from placing any credence in the results of this modeling exercise. It is axiomatic that a modeler must be diligent to set up his model in a manner that is consistent with the conditions, circumstances or events that he is modeling if the "predictions" or "simulations" of that model are to have any utility in evaluating what actually happened or will happen in the real world. The model put forward by Dr. Engel fundamentally misrepresents the real environment of the IRW and the litter application practices at issue.

First, in the artificial reality created by Dr. Engel in his model, numerous sources known to contribute phosphorus to streams and rivers are either assumed not to exist or are manipulated in an attempt to conceal the magnitude of their real-world impact. For example, the contributions of phosphorus from stream bank erosion, septic tanks and sewage bypasses at treatment plants and commercial fertilizer imported into the IRW were not included in Dr. Engel's model. Ex. 2, Engel Dep., pp. 306-07, 444-45. Because his modeling and source allocation work ignores other known sources of phosphorus, the results of his work is unreliable.

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[13] Watershed-scale models do, of course, exist. One such model is the SWAT model. The SWAT model was used in a 2006 project completed for ODEQ by OSU's Dr. Daniel Storm to evaluate phosphorus sources and transport in the IRW. Ex. 8, ODEQ Illinois River Upland and In-Stream Phosphorus Modeling Final Report (6/28/06). Dr. Storm used a watershed scale model instead of a field-scale model such as GLEAMs because "some of the in-stream processes are significant" and those processes are not addressed in field-scale models. Ex. 9, Storm Dep., pp. 208-09. The results reported by Dr. Storm and ODEQ from their 2006 modeling are markedly different than the opinions that Dr. Engel now seeks to offer to this Court. The ODEQ model predicted that "applications of poultry litter were responsible for *only 15%* of the total annual phosphorus load reaching Lake Tenkiller" *as compared to the 45% -59% predictions by Dr. Engel. Id.*, p. 246.

See, e.g., City of Wichita v. Trustees of APCO Oil Corp. Liquidating Trust, 306 F. Supp. 2d 1040, 1109-10 (D. Kan. 2003) (rejecting as unreliable groundwater modeling it failed to account for alternate sources); *Kalamazoo River Study Group v. Eaton Corp.*, 258 F. Supp. 2d 736, 756-57 (W.D. Mich. 2003) (discussing need to consider alternate sources in fate and transport analysis). In fact, in previous testimony in this Court, Dr. Engel questioned the reliability of the work of another modeler for failing to include known potential sources in his watershed model. Ex. 3, pp. 460-61. Dr. Engel went so far as to say the expert under review in that case should have had "a written policy, a written protocol before conducting the modeling that would have clearly identified, you know, what the thresholds are, you know, what the decision-making process is going to be as to whether things are excluded." *Id.* Despite this prior admonishment of another expert, Dr. Engel was forced to admit in his deposition that he committed the very same infraction in this case because he also failed to develop a written protocol for deciding whether to include or exclude a potential source of phosphorus from his modeling exercise. Ex. 2, Engel Dep., pp. 442-44. As Dr. Engel explained in previous testimony in this Court, "when you exclude some of the potential sources, you have to end up attributing some of this phosphorus that does end up at the lakes to sources you did include. So that increases the uncertainty, decreases the reliability of some of those estimates." Ex. 3, Hrg. Tr., p. 461.

Even more egregious than ignoring the sources described above is Dr. Engel's blatant manipulation of the data regarding cattle manure, a known substantial source of phosphorus in the IRW. Seven million seven hundred ninety thousand (7,790,000) pounds of phosphorus per year are deposited by cattle to the land in the IRW according to Dr. Engel. Ex. 1, Engel Rpt., E-1. When ODEQ modeled sources in the IRW using the more-sophisticated, watershed-scale SWAT model, it concluded that "approximately 21% of the phosphorus load to Lake Tenkiller was attributable to cattle." Ex. 9, Storm Dep., p. 246. In Dr. Engel's modeling, however, cattle

only accounted for 6% of the total phosphorus load to Lake Tenkiller. Obviously, these reports stand in contrast to each other. The significant difference in the source allocations is due to the fact that Dr. Engel employed a series of clearly unfounded assumptions to magically shrink the contribution of cattle in his modeling and load allocation work. First, he assumed, without any basis, that cattle grazing on fields that have access to first or second order streams (as opposed to larger tributaries) cannot contribute phosphorus. Ex. 2, Engel Dep., pp. 400-02 (Engel now admits that cattle manure deposited in or near first and second order streams (i.e., smaller streams) can contribute phosphorus during rain events even though he excluded those contributions from his load allocation). Next, Dr. Engel assumed that with respect to pastures adjoining larger streams, only that manure deposited by cattle within 10 meters of those streams could be transported to the water. *Id.*, pp. 358, 393-94.[14] The combined effect of these first two assumptions was to reduce the potential phosphorus from cattle from 7,790,000 pounds of phosphorus per year down to 35,594 pounds of phosphorus per year. Ex. 1, Engel Rpt., F-3 (Table 6). Then finally, Dr. Engel further reduced the potential phosphorus from cattle by another 45% based upon a brief telephone conversation in which he claims that Ed Fite (OSRC Administrator) told him that 45% of the cattle grazing on pastures that adjoin larger streams and rivers cannot deposit manure in or near streams because they have been fenced out of those areas. *Id.*, pp. 395-99. In his deposition, Mr. Fite stated that he was unaware that his "windshield" assessment would be used as the basis for supposedly scientific opinions in this litigation. Ex. 10, Fite Dep., pp. 106-09. Mr. Fite describes his "windshield" assessment as "hit and miss" and readily agreed that he had not done sufficient analysis to feel comfortable offering

[14] Dr. Engel, of course, makes no corresponding assumption with respect to poultry litter. Unlike cattle manure, Dr. Engel's model assumes that poultry litter applied 20 meters, 100 meters, 1,000 meters or even several miles away from a stream can contribute phosphorus to Lake Tenkiller.

an opinion to a reasonable degree of certainty as to the percentage of cattle that are fenced out of streams in the IRW. *Id.*, pp. 106, 109.

Dr. Engel's unreasonable and unrealistic characterization of potential sources did not end with cattle. His model severely misrepresents the potential source that it was put forward to indict in this case, that being poultry litter applications. The assumptions made by Dr. Engel with respect to when, where and how poultry litter is applied in the IRW are so far off the mark that these assumptions standing alone render his model an unreliable basis for offering any opinion about the relative contribution of poultry litter to the total phosphorus load to Lake Tenkiller. Dr. Engel assumed that all litter generated in the IRW is applied in the IRW. Ex. 2, Engel Dep., p. 233. This led Dr. Engel to simulate in his model 354,000 tons of poultry litter applications annually despite the fact that the ODAFF and ANRC records reviewed by him showed that far fewer tons of poultry were applied in the IRW on an annual basis. *Id.*, pp. 247-52. Dr. Engel further assumed that each and every parcel of land in the 1.1 million acre IRW that was identified as "pastureland" in his land use dataset received poultry litter applications every year. *Id.*, p. 253. When confronted with the undeniable truth that not all pastures in the IRW receive litter applications, Dr. Engel's only response was "for purposes of the model study, it wasn't necessary to reflect the actual spreading patterns." *Id.*, p. 256. Because Dr. Engel's model spread poultry litter across far more pasture acreage than could ever actually receive litter in a given year, his simulated land applications do not comport with the common practices in the IRW that he was supposed to be modeling. *Id.*, pp. 318-25 (simulated application rates ranged from *.1 to 1.05* tons/acre *compared to* "typical application rates" of *2 tons* per acre.) Dr. Engel's last and perhaps most absurd assumption regarding litter applications within his modeling was his assumption that all 354,000 tons of litter applications simulated in his model occurred on a single day – April 1st. *Id.*, p. 257. Of course, not all litter is applied on the same day or even

within the same month. In fact, the litter application records available to Dr. Engel indicated that only 17% of litter applications in the IRW occur in the entire month of April and that no single month (much less a single day) accounts for more than 20% of the annual litter applications. *Id.*, p. 258. Given the failure of Dr. Engel to properly characterize poultry litter applications within his model, the results of that modeling exercise are in no way a reasonable and reliable simulation of the impacts of this potential source.

The wild and supported assumptions by Dr. Engel continued in his forecasts of anticipated phosphorus loads to Lake Tenkiller 50 to 100 years into the future. *See* Ex. 1, Engel Rpt. (5/22/08), pp. 48-92 (continued waste application scenario, waste cessation scenario, 50 year growth scenario and waste cessation plus buffers scenario). In the model runs upon which these forecasts are based, Dr. Engel assumed that there would be no changes in weather patterns, land uses, residential or industrial development or growth in the human population in the IRW within the next 50 to 100 years. Ex. 2, Engel Dep., pp. 79-82. Dr. Engel agrees that these changes would likely occur, but explained that he did not model their effects because the lawyers had not asked him to describe what is actually likely to occur in the watershed. *Id.*, pp. 83-84.

Expert work must "have a valid scientific connection to the disputed facts in the case" in order to satisfy the relevancy and reliability tests for scientific evidence under *Daubert*. *Allison v. McGhan*, 184 F.3d 1300, 1312 (11th Cir. 1999). The alternative universe created by Dr. Engel with his computer models bears no resemblance to the real IRW. His predictions based upon the results of these models will not assist the trier of the fact in this case because those predictions are the product of unfounded assumptions or deliberate manipulations. As such, the modeling and source allocation work of Dr. Engel is unreliable.

C. The Models Relied Upon by Dr. Engel Have Not Been Properly Calibrated, Validated or Tested

"Proposed testimony must be supported by appropriate validation" external from the proponent's own work. *Daubert* 590 U.S. at 590. EPA guidance on the use of models recommends a series of tests that should be conducted by a modeler to "corroborate" or confirm that his model is accurately and reliably simulating real world conditions. Ex. 11, EPA Guidance (2009), p. 64 ("In this guidance, corroboration is defined as all quantitative and qualitative methods for evaluating the degree to which a model corresponds to reality. In practical terms, it is the process of 'confronting models with data'. . . . In some disciplines, this process has been referred to as validation."). The most common and generally accepted tests to corroborate hydrologic models include sensitivity analysis, calibration and validation. *Id.*, pp. 22, 28, 64.

As Dr. Bierman explains, "sensitivity analysis investigates how model outputs are affected by changes in selected model inputs." Ex. 6, Bierman Rpt., p. 16. EPA recommends conducting sensitivity analysis as a part of hydrologic modeling in order to identify and characterize potential sources of uncertainty in the model results. Ex. 11, EPA Guidance (2009), pp. 69-70. In his deposition, Dr. Engel admitted that he conducted no sensitivity analysis with respect to his use of the GLEAMS model on the IRW. Ex. 2, Engel Dep., p. 464. This is a surprising turn of events given that six years ago, Dr. Engel testified in this very Court as to the importance of conducting sensitivity analysis on hydrologic models. Ex. 3, Hrg. Tr., p. 462 ("certainly a sensitivity analysis . . . and observing what happens in the model response would be helpful . . . to better identify the impact of some of those kinds of assumptions and how those would impact how you attribute the phosphorus sources."); and p. 466 ("There was limited parameter sensitivity analysis that was conducted here. I would have liked to have seen more of that."). After criticizing a colleague for conducting "limited" sensitivity analysis, Dr. Engel has

now put before the Court a model in which he conducted "no sensitivity analysis" whatsoever.

Calibration and validation are also critically important steps in evaluating the reliability of predictions from a hydrologic model. "Calibration is the process of adjusting model parameters until the resulting predictions give the best possible fit to the observed data." Ex. 6, Bierman Rpt., p. 19. Validation, as that term is used by Dr. Engel, "is a subsequent testing of a pre-calibrated model with additional field data, usually under different external conditions, to further examine the model's ability to predict future conditions." Ex. 1, Engel Rpt., p. 20. Dr. Engel claims to have calibrated and validated both the GLEAMS model and his phosphorus routing model, but in reality he did not.

First, Dr. Engel did not even attempt to calibrate his models for sediment transport -- a step he had previously acknowledged as standard procedure in a published paper. Ex. 2, Engel Dep., pp. 325-26. His justification for skipping this part of the calibration was a belief that "sediment was not a significant pathway of movement of phosphorus through – through the system to Lake Tenkiller." *Id.*, p. 326. This belief is at odds with the opinion of Plaintiffs' lake expert, Dr. Scott Wells, who testified that sediment was a significant source of phosphorus loading to Lake Tenkiller. Ex. 12, Wells Dep., p. 279. Thus, Dr. Engel's models are uncalibrated with respect to an admittedly important source of phosphorus delivery to Lake Tenkiller.

Second, Dr. Engel did absolutely nothing to calibrate or validate the non-point source loading predictions generated by the GLEAMS model which were in turn "delivered" to Lake Tenkiller by his phosphorus routing model. Given that this case is premised upon claims of non-point source pollution, it is remarkable that Dr. Engel neglected to evaluate the reliability of his model's prediction of the potential magnitude of phosphorus loadings from non-point sources. Dr. Engel had available to him edge-of-field phosphorus data collected by Plaintiffs'

other experts from the IRW,[15] but he failed to compare any of the predictions of his GLEAMS model about edge-of-field phosphorus contributions from non-point sources to any single edge-of-field sample. Ex. 2, Engel Dep., pp. 176-77. Dr. Engel claims that specific calibration of his model to the edge of field "wasn't necessary" because he calibrated his model to the total phosphorus load reaching three USGS gauging stations located in many instances 90 miles or more downstream from where GLEAMS predicts edge-of-field losses. *Id.*, p. 177. As Dr. Bierman explained in his report, this approach to calibration is "flawed" and "circular." Ex. 6, Bierman Rpt., pp. 17-19.

> Dr. Engel calibrated his GLEAMS model to phosphorus loads that are different than the phosphorus loads it actually predicts. GLEAMS predicts nonpoint source loads at edge-of-fields throughout the watershed, not phosphorus loads to Lake Tenkiller. These edge-of-field locations are far back upstream. For example, there is a distance of 94 river miles from USGS gauge near Tahlequah to the Plaintiffs' edge-of-field sampling location (EOF-Q3) near Sweetwater Creek. Comparing edge-of-field predictions to phosphorus concentrations 94 miles away tells us nothing about how his GLEAMS model corresponds to reality.

Id., p. 19. According to Dr. Bierman, "Dr. Engel's GLEAMS model should be independently calibrated to edge-of-field phosphorus data and the routing model should be independently calibrated to phosphorus data in streams and rivers and to phosphorus loads to Lake Tenkiller." *Id.* Dr. Bierman is not alone in this view. EPA's guidance on hydrologic models makes clear that "[w]hen employing linked models, the project team should evaluate each component model as well as the full system of integrated models at each stage of the model development and evaluation process." Ex. 11, EPA Guidance (2009), p. 12. SERA-17, a collection of some of the world's most renowned water quality modelers, has stated "watershed-scale predictions of loadings to lakes are not reliable unless extensive, site-specific calibration is

[15] Plaintiffs collected edge-of-field samples at 64 locations in the IRW and those samples produced 146 measurements. Ex. 6, Bierman Rpt., p. 17.

used." Ex. 13, SERA-17 *Predicting Phosphorus Losses* (2005), p. 3.[16] Because Dr. Engel failed to test or corroborate his model by confronting it with data sufficient to allow one to determine whether the predictions are reasonably accurate reflections of the real world, this Court can place no confidence in the results of these models or the opinions expressed by Dr. Engel based upon those results.

To demonstrate the lack of utility and reliability in Dr. Engel's models, Defendants asked Dr. Bierman to run various tests using different input data with Dr. Engel's models.[17] In one test, Dr. Bierman reversed the predicted phosphorus loads from GLEAMS for the time period of 1986-2006 and then re-ran Dr. Engel's phosphorus routing model. He got essentially the same results at Lake Tenkiller that Dr. Engel got. Ex. 6, Bierman Rpt., p. 29. As Dr. Bierman explains, "because predicted daily phosphorus loads from . . . GLEAMS are driven by rainfall events . . . this means that Dr. Engel's linked GLEAMS and routing model cannot tell the difference between rainy days and dry days in the IRW." *Id.* Another test ran by Dr. Bierman confirmed that Dr. Engel's models are unimpacted by changes in the human population in the IRW and resulting changes of the magnitude of point source discharges from waste water treatment plants ("WWTPs"). To test this, Dr. Bierman increased the point source discharge assumed in these models by 345-fold to reflect 97 million people served by these WWTPs as

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[16] SERA-17 is an organization of research scientists, policy makers, extension personnel and educators. The mission of this organization is to develop and promote innovative solutions to minimize phosphorus losses from agriculture by supporting, among other things, phosphorus management and research. Ex. 6, Bierman Rpt., p. 6.

[17] This is a commonly employed technique for testing the validity and uncertainty of models and their input data. Dr. Engel is well aware of this technique having suggested something very similar to test the reliability of the hydrologic model under review in the *City of Tulsa* case. Ex. 3, Hrg. Tr., p. 466 ("it would have been interesting to see what happens if we do take the defendants' chicken litter numbers and apply those at face value, see what the model predicts. There are many other assumptions of that sort or many other alterations of some of the data that could be made to explore how those propagate through the model and what net impact on the results that they may have.")

opposed to Dr. Engel's estimated population of 280,000. When the models were re-run with these dramatic changes, the results in terms of estimated loads to Lake Tenkiller do not change materially. *Id.*, p. 30. In another test, Dr. Bierman confirmed that Dr. Engel's models cannot differentiate between phosphorus loads and completely random input values such as the S&P 500 index. *Id.*, p. 31 (using the completely random input of the reported S&P 500 daily index in the place of Dr. Engel's predicted phosphorus loads from sources within the IRW yields materially identical results at Lake Tenkiller). Finally, and most remarkably, Dr. Bierman determined that he could add poultry litter from an additional two billion birds per year in the IRW to Dr. Engel's models and still achieve essentially the same estimated loadings to Lake Tenkiller. *Id.* Thus, Dr. Engel's models are not even capable of responding realistically to changes in the very source that they were intended to characterize and quantify. Simply put, Dr. Engel's models were not only not tested by him, they failed the tests applied by Dr. Bierman.

CONCLUSION

For the foregoing reasons, Dr. Engel's testimony should be excluded as unreliable under *Daubert*.

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